

***Cirsium tatakaense* (Compositae), a new species from Taiwan**

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Abstract

A new species of *Cirsium*, *Cirsium tatakaense* Y.H.Tseng & C.Y.Chang, from central-southern Taiwan is described and illustrated. This species is similar to *C. kawakamii* Hayata in leaf shape, achene and chromosome number ($2n = 64$), but can be readily distinguished from *C. kawakamii* by the narrower leaf lobes, usually higher number of florets and phyllaries, the purplish-red corolla (vs. white) and larger pollen grains. A key to the species of *Cirsium* in Taiwan is also presented.

Keywords

New species, Chromosome number, *Cirsium tatakaense*, *Cirsium kawakamii*, Compositae, Taiwan

Introduction

Cirsium Mill. is a genus of Compositae and comprises approximately 250 species widely distributed throughout the world's temperate and subtropical zones (Kadota 2007). A total of 46 species are native to China (Shih and Greuter 2011), 64 to Japan (Iwatsuki et al. 1995) and 9 to Taiwan (Peng 2003).

Kitamura (1937) established the first infrageneric classification for East Asian *Cirsium*. In this classification, the Taiwanese species were placed in two of the sections, sect. *Pseudoeriolepis* (Nakai) Kitam. and sect. *Onotrophe* (Cass.) DC. and five subsections, subsect. *Arenicola* Kitam., subsect. *Australicirsium* Kitam., subsect. *Nipponocirsium* Kitam., subsect. *Sinocirsium* Kitam. and subsect. *Spanioptilon* Less. The latter subsection was subsequently raised to the rank of section (sect. *Spanioptilon* (Less.) Shih) by Shih (1984) and maintained by Iwatsuki et al. (1995).

Recently, we discovered a rare *Cirsium* growing in the high mountain areas of central-southern Taiwan. Based on the systems of Kitamura (1937) and Iwatsuki et al. (1995), this taxon belonged to section *Onotrophe* subsection *Nipponocirsium* and appeared to be similar to *Cirsium kawakamii* Hayata, sharing the longer leaf lobes, nodding bowl-shaped mature capitula and corolla lobes as long as the inflated part of the corolla tube.

Materials and methods

We compared the new species to the other two species of *Cirsium* sect. *Onotrophe* in Taiwan.

Herbarium examination

Materials primarily comprised fresh and dried specimens; voucher specimens were deposited in TCF, PPI and TNM. The herbaria referenced included HAST, KYO, PPI, TAI, TAIF, TCF, TI and TNM.

Pollen morphology

Pollen grains, all from fresh material, were directly mounted on a stub without any pretreatment and sputter coated with gold (Quorum SC7620) for observation with a scanning electron microscope (Hitachi S-3400N). The shape, size and exine ornamentation were studied following Erdtman (1952) and Hesse et al. (2009). Vouchers for the pollen material studied are provided in Table 1.

Table 1. Voucher material for the *Cirsium* Mill. pollen morphology.

Taxa	Location	Coordinate	Altitude	Date	Voucher
<i>C. tatakaense</i>	TAIWAN. Kaohsiung City Tauyuan District, Kuaiku to Yakou	23°16.03'N, 120°56.24'E	2600 m	21 Oct 2014	<i>C. Y. Chang</i> , 160 (TNM)
	TAIWAN. Nantou County Sinyi Township, Tataka	23°29.24'N, 120°52.71'E	2620 m	15 Nov 2014	<i>C. Y. Chang</i> 182 (TCF)
	TAIWAN. Nantou County Sinyi Township, Tataka to Shihshan	23°28.56'N, 120°52.74'E	2530 m	26 Oct 2015	<i>C. Y. Chang</i> , 842 (TNM)
	TAIWAN. Nantou County Sinyi Township, Tataka to Shihshan	23°29.24'N, 120°52.71'E	2631 m	22 Dec 2015	<i>C. Y. Chang</i> 1017 (TCF)
<i>C. kawakamii</i>	TAIWAN. Taichung City Heping District, Mt. Pintian to Mt. Dabajian	24°26.52'N, 121°15.83'E	2800 m	13 Aug 2014	<i>C. Y. Chang</i> 264 (TNM)
	TAIWAN. Taichung City Heping District, Mt. Syue Trail 8.9 km	24°23.53'N, 121°14.20'E	3500 m	3 Oct 2015	<i>C. Y. Chang</i> 774 (TCF)
	TAIWAN. Nantou County Ren'ai Township, Nengao cross-ridge historic trail 11 km	24°2.79'N, 121°15.77'E	2600 m	29 Jan 2018	<i>C. Y. Chang</i> 1605 (TNM)
<i>C. arisanense</i>	TAIWAN. Taichung City Heping District, Mt. Syue trail 8.9 km	24°23.60'N, 121°13.98'E	3450 m	3 Sept 2015	<i>C. Y. Chang</i> 756 (TCF)
	TAIWAN. Nantou County Ren'ai Township, Rueiyan river pipes road 2 km	24°06.95'N, 121°11.96'E	2240 m	27 May 2016	<i>C. Y. Chang</i> 1275 (TCF)

Table 2. Voucher material for the *Cirsium* Mill. karyotype analysis.

Taxa	Location	Coordinate	Altitude	Date	Voucher
<i>C. tatakaense</i>	TAIWAN. Chiayi County Alishan Township, Tataka to Paiyun lodge	24°28.40'N, 120°54.23'E	2800 m	15 May 2016	<i>C. Y. Chang</i> 1269 (TCF)
<i>C. kawakamii</i>	TAIWAN. Taichung city Heping District, Mt. Syue trail 8.9 km	24°23.73'N, 121°13.94'E	3371 m	8 Nov 2015	<i>C. Y. Chang</i> 874 (TCF)
	TAIWAN. Taichung city Heping District, Mt. Syue trail 8.9 km	24°23.73'N, 121°13.94'E	3371 m	21 May 2016	<i>C. Y. Chang</i> 1271 (TCF)

Karyotype analysis

Karyotype analysis was performed by following the same procedure applied by Ozcan et al. (2011) and Yüksel et al. (2013). Root tips were collected on sunny mornings and preserved in 0.002 M 8-hydroxyquinoline solution below 10 °C for eight hours. This material was then fixed with Carnoy's solution (1 part acetic acid: 3 parts EtOH) for at least 24 hours at 4 °C. The fixed roots were then stained with acetic-orcein for 24 hours at room temperature, squashed and the slides examined using an stereo microscope (ACCU-ScoPE 3025). Voucher material is presented in Table 2.

Results and discussion

Morphological comparison

Following Kitamura (1937) and Iwatsuki et al. (1995), *Cirsium tatakaense* is placed in section *Onotrophe* together with *C. kawakamii* and *C. arisanense*. Amongst them, *C. arisanense* belongs to subsection *Australicirsium*, which is characterised by having rosette leaves, pot-shaped capitula which are erect or nodding when mature, corolla lobes equal in length to the inflated part of corolla tube and corona-like achene beaks. Both *C. tatakaense* and *C. kawakamii* belong to subsection *Nipponocirsium*, which is characterized by not having rosette leaves, larger bowl-shaped capitula which are nodding when mature, corolla lobes equal in length to the inflated corolla tube and tube-like achene beaks. In comparison with *C. kawakamii* (Table 3), *C. tatakaense* has purplish corolla (vs. white in *C. kawakamii*) (Figure 5[2]), usually more florets (136)161–308 (vs. (61)115–222 in *C. kawakamii*) (Figure 5[2]) and phyllaries 111–199 (vs. 79–123 in *C. kawakamii*) (Figure 5[2]) and narrower leaf lobes 7.3–11.9 mm (vs. 17.2–18.6 mm in *C. kawakamii*) (Figure 5[1]).

Chromosome number

The basic number of chromosomes amongst *Cirsium* species is often $2n = 34$ (Hsu 1970; Funk et al. 2009; Chen and Yeh 2010a; Chen and Yeh 2010b), including in *C. arisanense* (Peng and Hsu 1978). However, the chromosome number of *C. tatakaense* is $2n = 64$ (Fig. 6A), which is the same as that of *C. kawakamii* (Fig. 6B), indicating that

the two species are similar in this respect. Notably, other taxa of the same subsection in Japan are $2n = 68$ (Iwatsuki et al. 1995). These findings imply that subsect. *Nipponocirsium* are tetraploids with aneuploid cells.

Palynological study

Cirsium tatakaense pollen has a larger diameter, up to 36–43 μm (vs. 32–35 μm in *C. kawakamii*) and its surface spines have broader bases of 4.2–5.6 μm (vs. 2.0–2.3 μm in *C. kawakamii*). The pollen grains of *C. tatakaense* are similar to *C. arisanense* (Fig. 7A, C). However, *C. kawakamii* (similar to *C. tatakaense* in macroscopic morphology) has the smallest pollen grains and spine in Taiwan (Fig. 7B). Pollen morphology is associated with pollination, thus implying reproductive isolation between the two species.

Comparison of the distribution between *C. tatakaense* and *C. kawakamii*

Compared with *C. tatakaense*, *C. kawakamii* occurs at higher altitudes (up to 3500 m); *C. tatakaense* is seldom discovered over altitudes of 3000 m. In addition, *C. kawakamii* is usually distributed in alpine gullies and valleys, whereas *C. tatakaense* often appears on spacious roadsides, seemingly with no preference for valley habitats. Therefore, we believe that *C. kawakamii* prefers shaded and moist environments, whereas *C. tatakaense* prefers open areas with higher drought tolerance. Some geographical segregation appears to exist in the distributions of *C. tatakaense* and *C. kawakamii*.

Table 3. Summary of characters between the species of *Cirsium* sect. *Onotrophe* in Taiwan.

Characters	<i>C. tatakaense</i>	<i>C. kawakamii</i>	<i>C. arisanense</i>
Leaf size (cm)	27.2–34.8 cm \times 16.4–19.4 cm	27.5–30.6 cm \times 17.8–20.2 cm	10.6–21.3 cm \times 3.0–6.3 cm
Leaf shape	Elliptic to broadly elliptic	Elliptic to broadly elliptic	Narrowly elliptic to deltoid
Leaf margin	Mainly pinnatisect	Pinnatisect or bipinnatisect	Pinnatipartite or bipinnatipartite
Leaf lobes Size	6.4–7.5 cm \times 7.3–11.9 mm	8.3–10.4 cm \times 17.2–18.6 mm	0.7–2.9 cm \times 6.6–16.0 mm
Pair of leaflobes	4–6	6–7	6–10
Mature Capitula	Nodding	Nodding	Erect or nodding
Involucre shape	Bowl-shaped (upper width \geq base)	Bowl-shaped (upper width \geq base)	Pot-shaped (upper width $<$ base)
Corolla colour	Purplish-red	White	Yellow
Floret number	(136)161–308	(61)115–222	87–133
Phyllary number	111–199	79–123	93–114
Beak of achene	Tube-like	Tube-like	Corona-like
Pollen size (P/E)	34.2–42.6 μm / 35.2–44.7 μm	31.7–34.5 μm / 34.3–37.1 μm	41.7–51.0 μm / 44.7–49.3 μm
Pollen spine base width	4.2–5.6 μm	2.0–2.3 μm	2.8–4.8 μm
Chromosome number	$2n = 64$	$2n = 64$	$2n = 34$ (Peng and Hsu 1978)
Distribution	Endemic to Taiwan; open areas of fog forests at 2000–3000 m alt. central-southern Taiwan (Fig. 3)	Endemic to Taiwan; gullies and valleys at 1500–3500 m alt. central-northern Taiwan (Fig. 3)	Endemic to Taiwan; widely distributed in open areas of mountain area at 1500–3800 m alt. (Fig. 3)

Taxonomic treatment

Key to the species of *Cirsium* Mill. in Taiwan

1 Biennial herb; involucre tube-shaped (length 2 times than width); corolla lobes < 2.5 mm long *C. ferum*

— Perennial herb; involucre pot or bowl-shaped (length approximates width), corolla lobes > 2.5 mm long 2

2 All leaves cauline, basal rosette leaves absent 3

— Leaves in both a basal rosette as well as cauline 5

3 Leaves densely cobwebbed on abaxial surface; mature capitula erect, involucre pot-shaped (upper width shorter than base); apical parts of inner phyllaries inflated, obtuse; outer phyllaries lanceolate, apex acute without spine; corolla lobes obviously longer than the inflated part of corolla tube *C. lineare*

— Leaves glabrous on both surfaces; mature capitula nodding, involucre bowl-shaped (upper width greater or equal to base); apical parts of inner phyllaries acute or acuminate; outer phyllaries elliptic with long spine at the apex; corolla lobes as long as the inflated part of corolla tube 4

4 Corollas white; leaves pinnatisect or bipinnatisect, lobes > 15 mm wide *C. kawakamii*

— Corollas purple; leaves mainly pinnatisect, lobes < 12 mm wide *C. tatakaense*

5 Phyllaries narrowly ovate 6

— Phyllaries subulate 7

6 Corollas white; phyllaries lanceolate, inner and outer phyllaries similar in length; stems cauline, without rhizome *C. brevicaule*

— Corollas purple; phyllaries narrowly ovate to ovate, inner and outer phyllaries distinct in length; stems both cauline and rhizomatous *C. morii*

7 Apical prominently parts of phyllaries longer than 4 mm, blade-like; corolla lobes as long as the inflated part of corolla tube 8

— Apical prominently parts of phyllaries shorter than 4 mm, spine-like; corolla lobes shorter than the inflated part of corolla tube 9

8 Leaf abaxial surface pubescent; mature capitula erect or nodding *C. arisanense*

— Leaf abaxial surface densely cobwebbed; mature capitula nodding *C. bosokawae*

9 Leaf abaxial surface densely cobwebbed; mature capitula nodding *C. suzukii*

— Leaves surface pubescent; mature capitula erect 10

10 Corollas purple; leaves surface shortly hairy *C. japonicum* var. *australe*

— Corollas white; leaves surface glabrescent *C. japonicum* var. *takaoense*

Species treatments

Cirsium kawakamii Hayata in J. Coll. Sci. Imp. Univ. Tokyo. 159. 1911.

Figs 4B, 5B, 6B, 7B

Type. TAIWAN. Mt. Morrison, ca. 3000 m alt., 20 Oct. 1906. *T. Kawakami & U. Mori* 2279 (holotype: TI!; isotype: TAIF!).

Description. Perennial herbs, stems 0.5–1.8 m tall, without rosette leaves. Leaves pinnatipartite or pinnatisect, 27.5–30.6 cm long and 17.8–20.2 cm wide, U-shaped space between pinnae, smooth, elliptic to broadly elliptic, base truncate to cuneate, apex caudate, pinnae 8.3–10.4 cm long and 17.2–18.6 mm wide, space between pinnae 2.5–3.0 cm, 6–7 pairs. Capitula arranged into racemes or panicles, mature capitula nodding, involucre bowl shaped, 3.4–3.8 cm long and 1.5–2.0 cm wide. Involucre lacking abaxial appendages, inner phyllaries acute apically, outer phyllaries green with indistinct layers, 1.6–1.8 cm long and 1.8–2.4 mm wide, protrusion 6.0–11.0 mm. Florets with white corolla, 2.8–3.1 cm long, corolla lobes 5.2–6.0 mm long and 0.4–0.7 mm wide; 5 synantherous stamens, detached filaments with irregular protuberances, basal caudate extensions, white or brown, anthers 5.4–8.2 mm long, filaments 6.8–8.0 mm long. Stigmas bifid apically, style 2.0–3.4 cm long, ovaries 1.5–2.0 mm long. Achenes oblong, base acute, apex truncate, beige, 4.3–4.9 mm long and 1.7–1.8 mm wide, long tube-shaped beak apically. Pappus 1.3–2.1 cm long forming basal ring, easily shed.

Phenology. Flowering between September and October and fruiting between October and November.

Distribution. Endemic to central-northern Taiwan. Preference for gullies and valleys at 1500–3500 m alt. (Fig. 3).

Chinese name. Yu-shan-ji (玉山薊).

Chromosome number. $2n=64$ (Fig. 6B).

Palynology. Pollen grains are tricolporate, spheroidal, microreticulate and $31.7\text{--}34.5 \times 34.3\text{--}37.1 \mu\text{m}$ (P/E ratio: 0.9–1.0). The surface is densely covered with spines that are 2.5–3.2 μm long and 2.1–2.2 μm wide at the base. The distance between spines is 7.6–8.8 μm (Fig. 7B).

Additional specimen examined. TAIWAN. Taoyuan City, Fuxing District, Mt. Lalashan, 1550–1700 m alt., 25 Sept. 1991. *C. I Peng* 14628 (HAST!). Miaoli County, Tai'an Township, Tunnel of Mt. Shishihshan to Mt. Huoshihshan, 2480 m alt., 18 Sept. 1995. *C. M. Wang* 1728 (TNM!). Taichung City, Heping District, Mt. Syue to Mt. Chi-hchiayangdashan, 3300 m alt., 10 Sept. 2014. *C. Y. Chang* et *C. H. Liu* 68 (TNM); Mt. Pintian to Mt. Dabajianshan, 2800 m alt., $24^{\circ}26.52'\text{N}$, $121^{\circ}15.83'\text{E}$, 13 Aug. 2014. *C. Y. Chang* 264 (TNM); Mt. Syue Trail 8.9 km, 3500 m alt., $24^{\circ}23.53'\text{N}$, $121^{\circ}14.20'\text{E}$, 3 Oct 2015. *C. Y. Chang* 774, 1271 (TCF). Nantou County, Ren'ai Township, Nengao cross-ridge historic trail 11 km, 2600 m alt., $24^{\circ}2.79'\text{N}$, $121^{\circ}15.77'\text{E}$, 29 Jan 2018. *C. Y. Chang* 1605 (TNM); Chengkung lodge, 3140 m alt., 31 July 2015. *C. Y. Chang* 654 (TNM); Guandao river, 22 Oct. 1932. *S. Sasao* s. n. (CHIA!); Mt. Hohwanshan, 3300 m alt., 15 Oct. 1994. *Tunghai Collecting Team* s. n. (TNM!). Hualien County, Xiulin Township, Sungshielou lodge to Dayuling, 3 Aug. 1974. *C. N. Lin* s. n. (KYO!).

***Cirsium tatakaense* Y.H.Tseng & C.Y.Chang, sp. nov.**

urn:lsid:ipni.org:names:77194985-1

Figs 1, 2, 4A, 5A, 6A, 7A

Diagnosis. Differs from *C. kawakamii* in having narrower leaf lobes (7.3–11.7 mm), usually more florets, (136)161–308 and phyllaries (111–199), a purplish-red corolla and larger pollen grains (34.2–42.6 × 35.2–44.7 µm).

Type. TAIWAN. Nantou County, Sinyi Township, Highway no. 18, Tataka to Shihshan, 2400 m alt., 23°28.52'N, 120°52.10'E, 3 October 2016. C. Y. Chang 1444 (holotype: TCF; isotype: TNM, PPI).

Description. Perennial herbs, stems 0.5–1.5 m tall, without rosette leaves. Leaves pinnatipartite or pinnatisect, 27.2–34.8 cm long and 16.4–19.4 cm wide, U-shaped space between pinnae, smooth, elliptic to broadly elliptic, base truncate to cuneate, apex caudate, pinnae 6.4–7.5 cm long and 7.3–11.9 mm wide, space between pinnae 2.9–3.0 cm, 4–6 pairs. Capitula arranged into racemes or panicles, mature capitula nodding, involucre bowl-shaped, 3.9–4.0 cm long and 1.7–2.1 cm wide. Involucre lacking abaxial appendages, inner phyllaries acute apically, outer phyllaries reddish-purple with indistinct layers, 1.1–2.2 cm long and 1.8–2.4 mm wide, protrusion 6.3–13.0 mm. Florets with purplish-red corolla, 3.2–3.3 cm long, corolla lobes 4.3–5.3 mm long and 0.4–0.7 mm wide; 5 synantherous stamens, detached filaments with irregular protuberances, basal caudate extensions, light purple or brown, anthers 6.4–6.8 mm long, filaments 7.1–8.1 mm long. Stigmas bifid apically, style 3.0–3.2 cm long, ovaries 1.7–1.9 mm long. Achenes oblong, base acute, apex truncate, beige, 3.0–3.5 mm long and 1.4–1.6 mm wide, long tube-shaped beak apically. Pappus 1.6–1.8 cm long forming basal ring, easily shed.

Phenology. Flowering between August and October and fruiting between September and November.

Distribution. Endemic species of Taiwan. *Cirsium tatakaense* is located in open areas of cloud forests of vegetation zones from the *Quercus* to *Abies* forest zone at alt. 2000–3000 m in central-southern Taiwan (Fig. 3). Based on the geographical climatic regions and vegetation zones (Su 1984, 1985), *C. tatakaense* is distributed mainly in the central-west inland regions. *Cirsium tatakaense* has been discovered in sunny environments, such as roadsides and forest margins, concentrated on the upper portions of hills along Provincial Highway no. 18. *Misanthus transmorrisonensis* Andersson (Poaceae), *Rubus taitoensis* Hayata (Rosaceae) and *Senecio nemorensis* L. var. *dentatus* (Kitam.) H. Koyama (Compositae) are often discovered with *C. tatakaense*. Sometimes, *C. arisanense* Kitam. and *C. ferum* Kitam. are found near to *C. tatakaense*; however, no hybrid individual between these species has been observed.

Chinese name. Ta-ta-jia-ji (塔塔加薊).

Etymology. The species epithet *tatakaense* derives from the type location Tataka in Nantou County.

Notes. This species has in the past been mistakenly identified as *C. kawakamii* (S. Saito 3477, KYO!; Yamazaki 945, KYO!; C. I Peng 8026, 8936, 11788, 14628, HAST!; K. F. Chung 1053, HAST!; Kawakami & Sasaki s. n., TAIF!; M. L. Weng 1723, TAI!; Y. Kudo

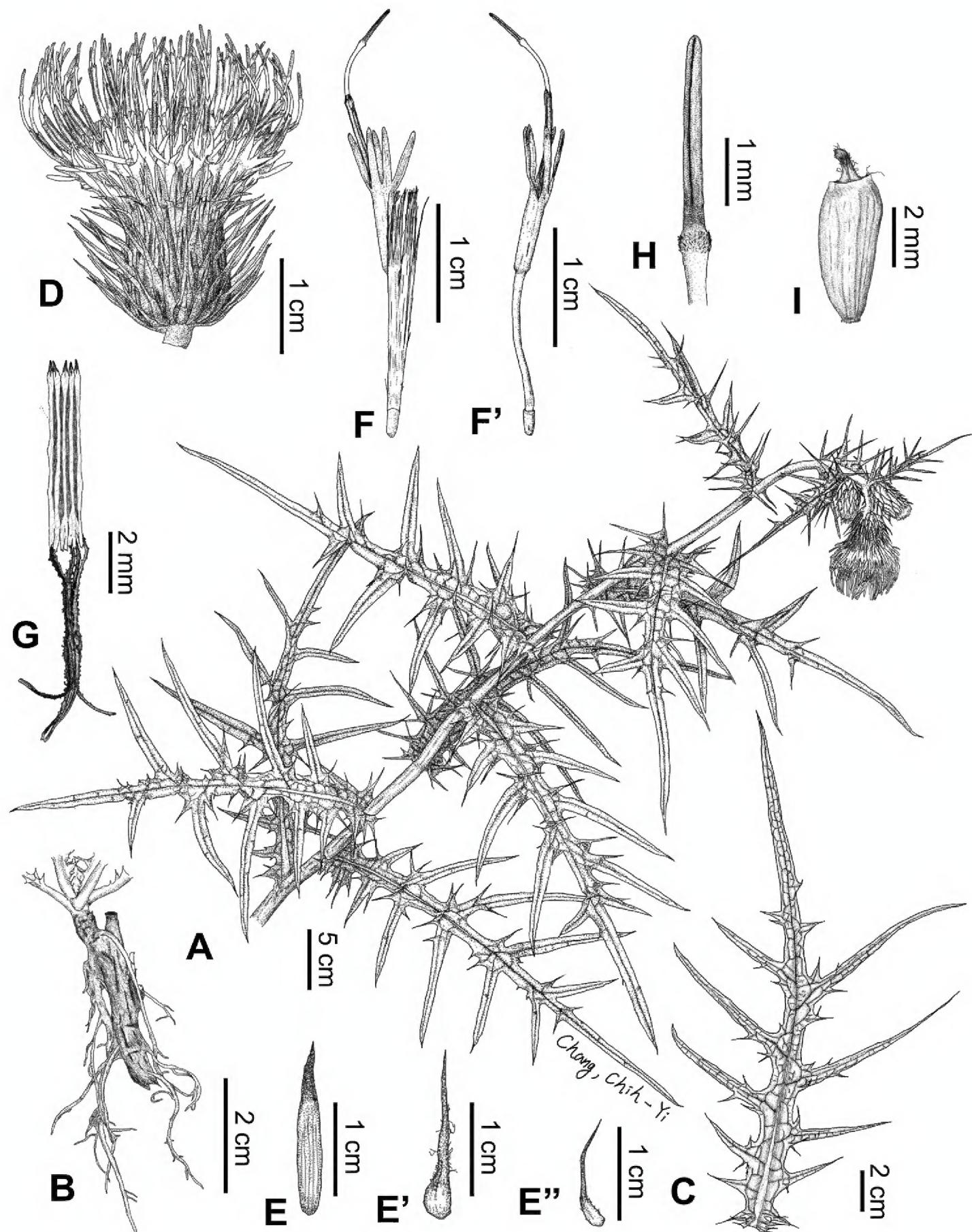


Figure 1. Line drawings of *Cirsium tatakaense* Y.H.Tseng & C.Y.Chang **A** habit **B** root **C** leaf **D** capitula **E** inner phyllary **E'** middle phyllary **E''** outer phyllary **F** floret **F'** floret (pappus removed) **G** synantherous **H** style branches **I** achene. Voucher: C. Y. Chang 1442 (TCF).

& S. Suzuki 300, TAI!; C. C. Hsu 4231, TAI!; C. I Peng 738, TAI!; C. T. Chao et al. 2534, TNM!; C. S. Kuoh 15146, TNM!) or less often as *C. arisanense* Kitam. (Yamamoto et al. 4142, TAI!; Y. J. Lin 169, PPI!). The earliest record of *C. tatakaense* was collected by T. Kawakami & S. Sasaki s. n. (TAIF!) at Mt. Morrison (alt. ca. 3000 m) on October 8, 1909.

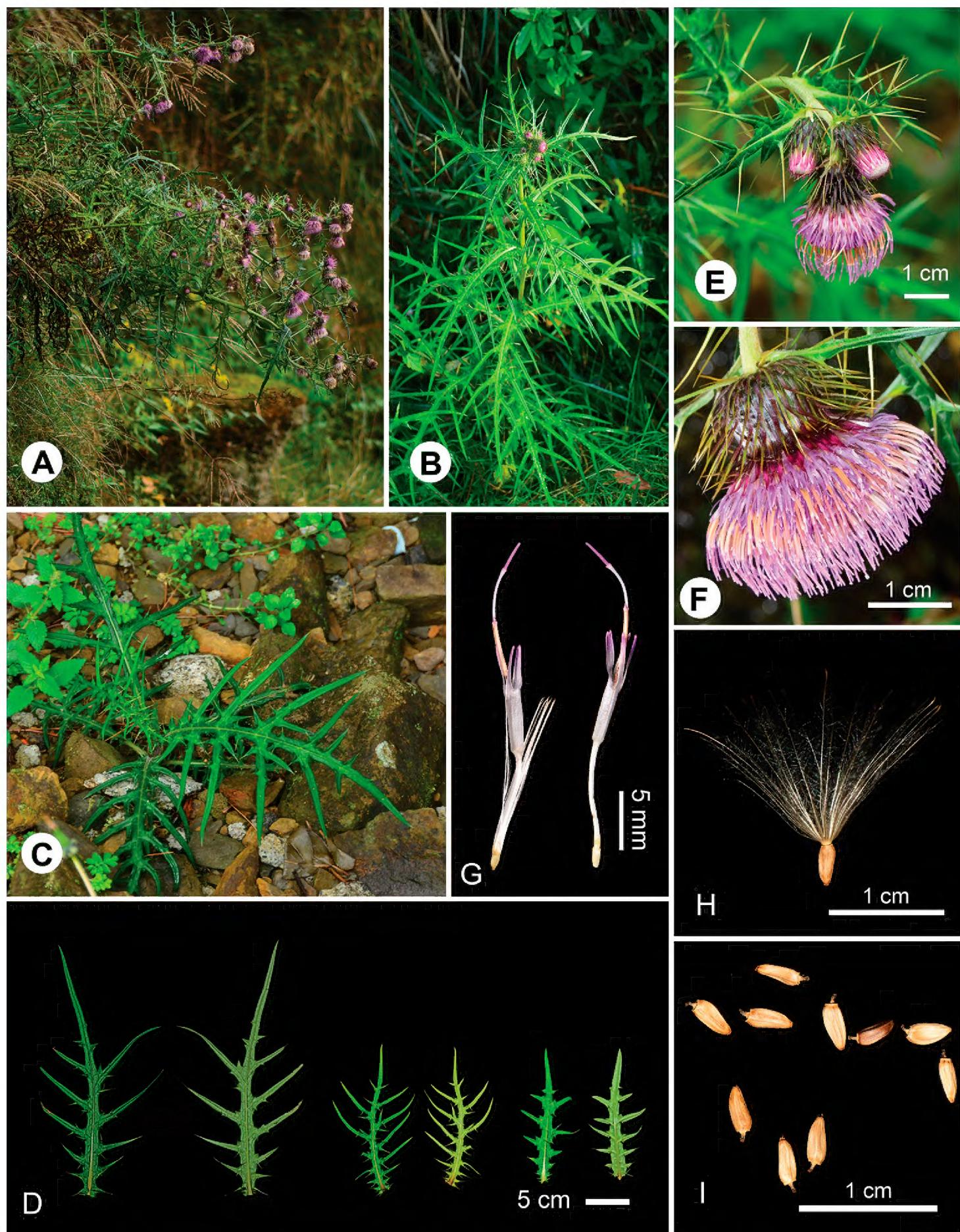


Figure 2. *Cirsium tatakaense* Y.H.Tseng & C.Y.Chang **A** habitat **B** habit **C** seedling **D** variations of leaves **E** inflorescences **F** capitula **G** floret; (right-side pappus removed) **H** achene with pappus **I** achene.

Other specimens collected from 1909–1930 were from Alishan (alt. ca. 2200 m). However, only a few populations remain in Alishan, with the largest population appearing along the Yushan Main Peak Trail from Tataka to Paiyun Lodge (alt. ca. 2800 m). We assume that use in herbal medicine as well as climate change have reduced the population of *C. tatakaense*.

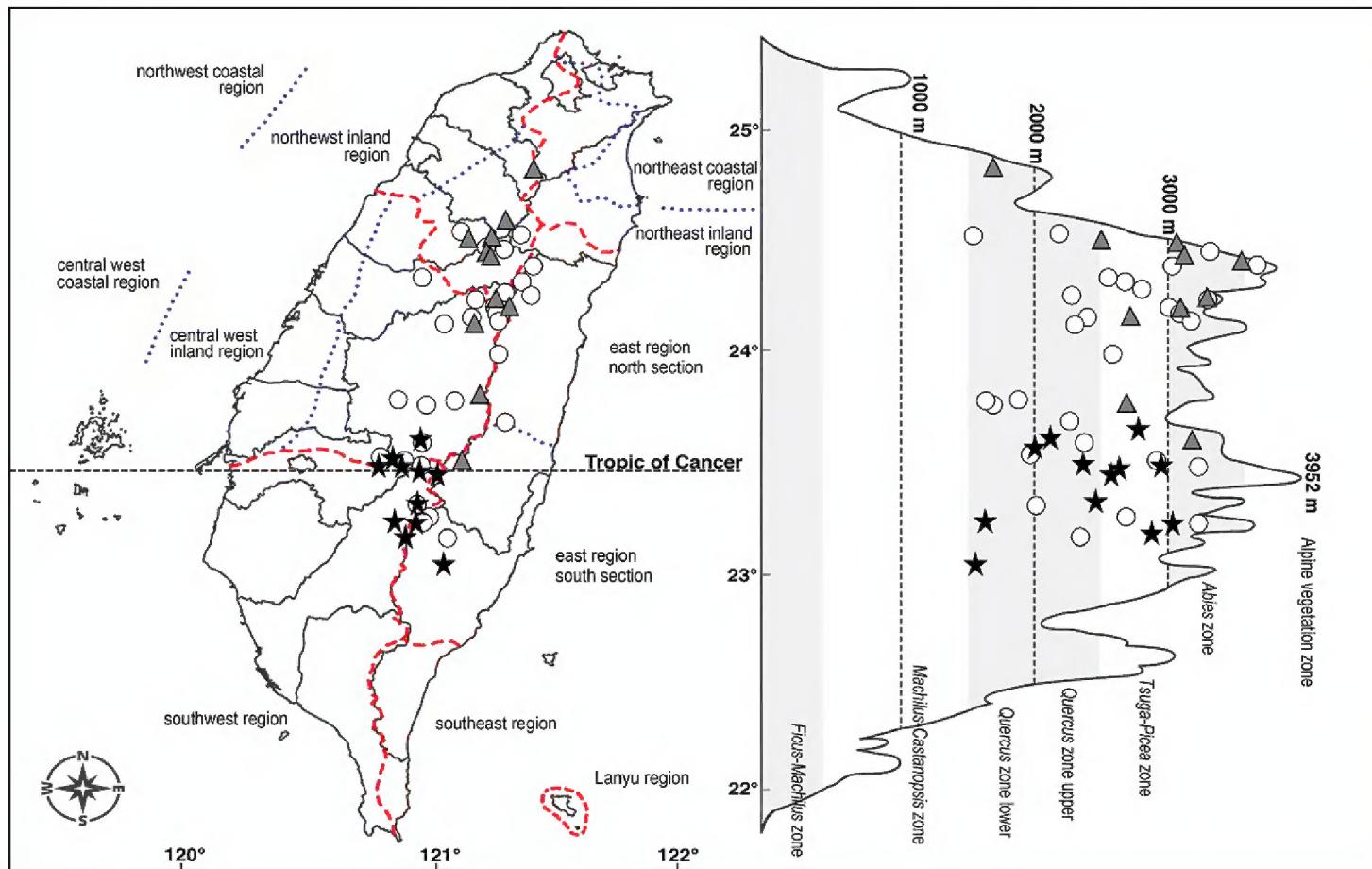


Figure 3. Distribution map of *Cirsium tatakaense* Y.H.Tseng & C.Y.Chang (star); *C. kawakamii* Hayata (triangle); and *C. arisanense* Kitam. (circle) of Taiwan.

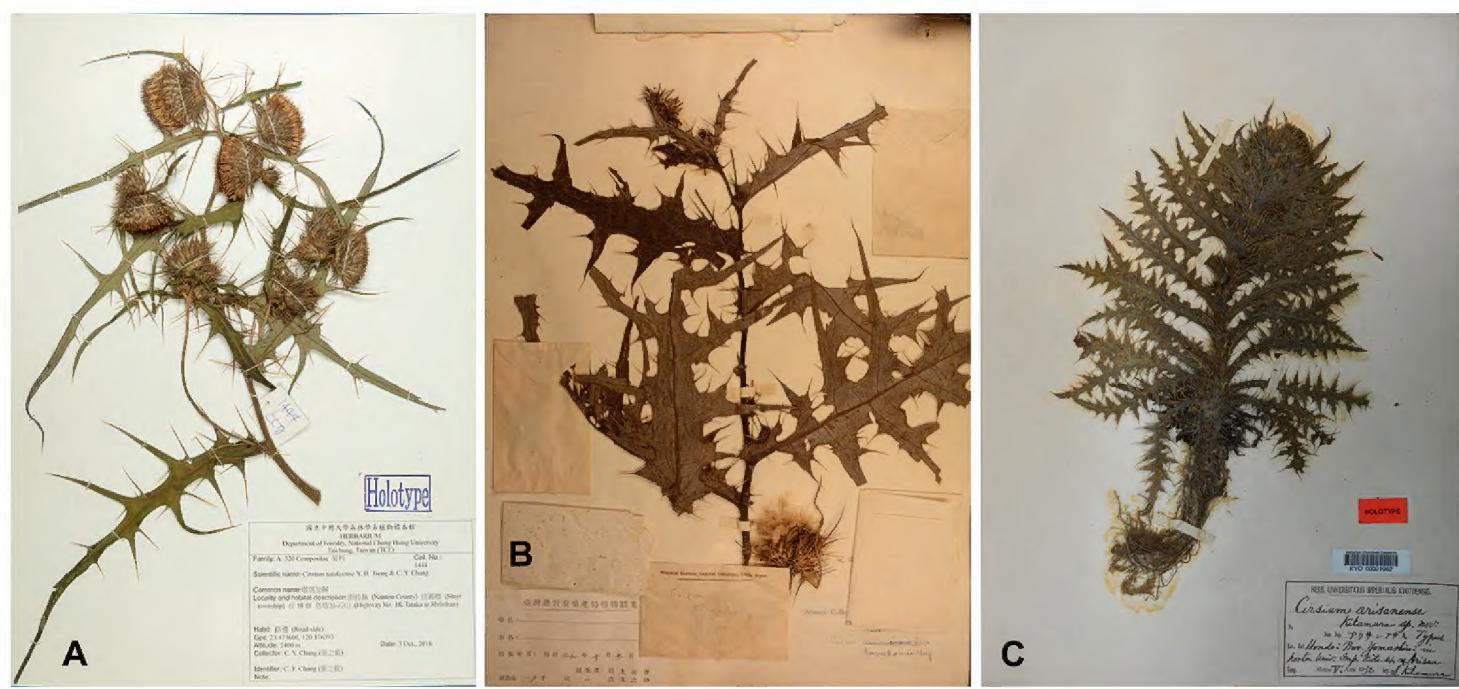


Figure 4. Holotypes of the three species of *Cirsium* sect. *Onotrophe* in Taiwan. **A** *C. tatakaense* Y.H.Tseng & C.Y.Chang, C. Y. Chang 1444 (TCF) **B** *C. kawakamii* Hayata, T. Kawakami & U. Mori 2279 (TI!) **C** *C. arisanense* Kitam., S. Kitamura s.n. (KYO!).

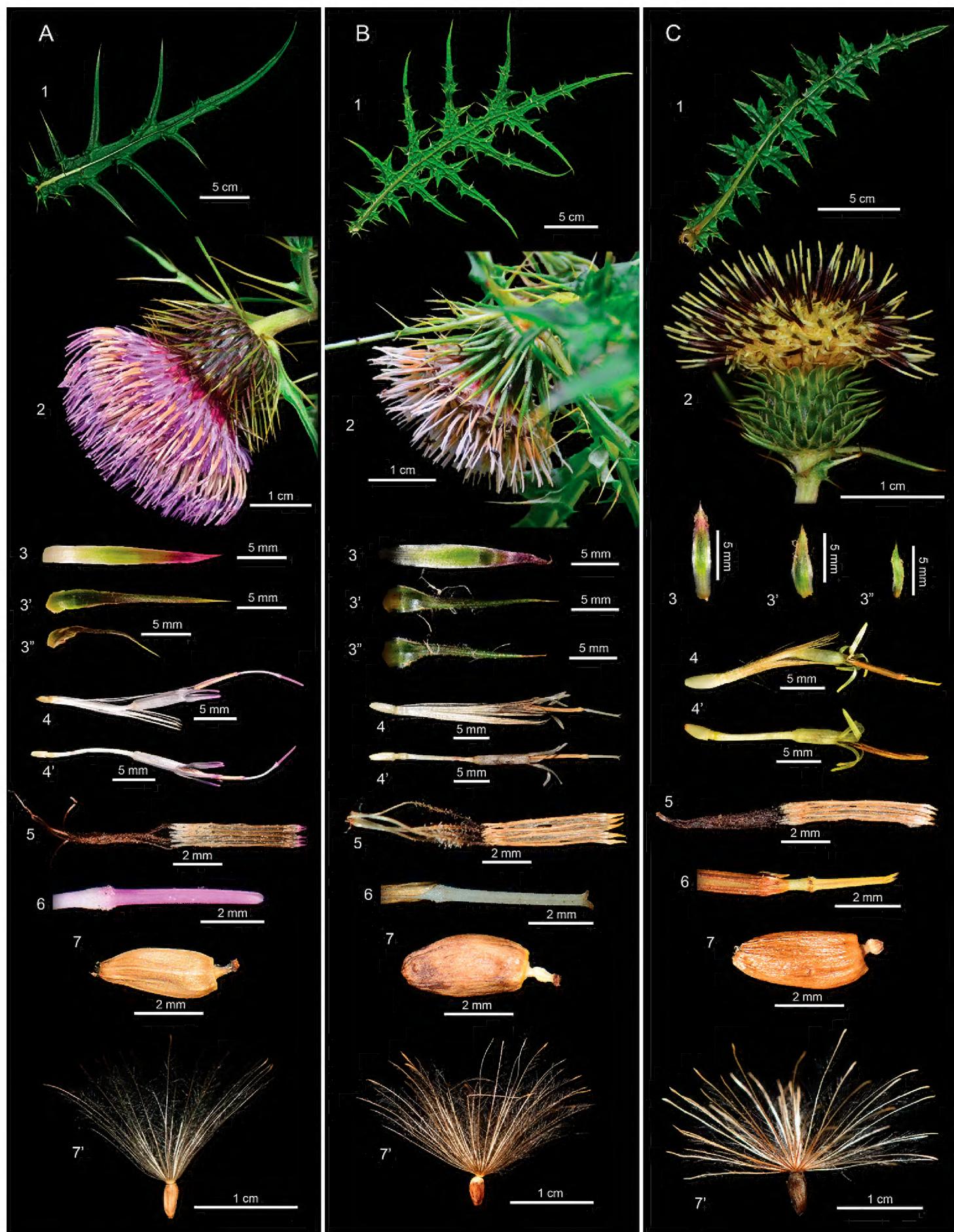


Figure 5. Comparison of the morphological characters amongst the species of *Cirsium* sect. *Onotrophe* in Taiwan. **A** *C. tatakaense* Y.H.Tseng & C.Y.Chang **B** *C. kawakamii* Hayata **C** *C. arisanense* Kitam.: 1 leaf 2 capitula 3 inner phyllary 3' middle phyllary 3'' outer phyllary 4 floret 4' floret (pappus removed) 5 synantherous 6 style branches 7 achene 7' achene with pappus.

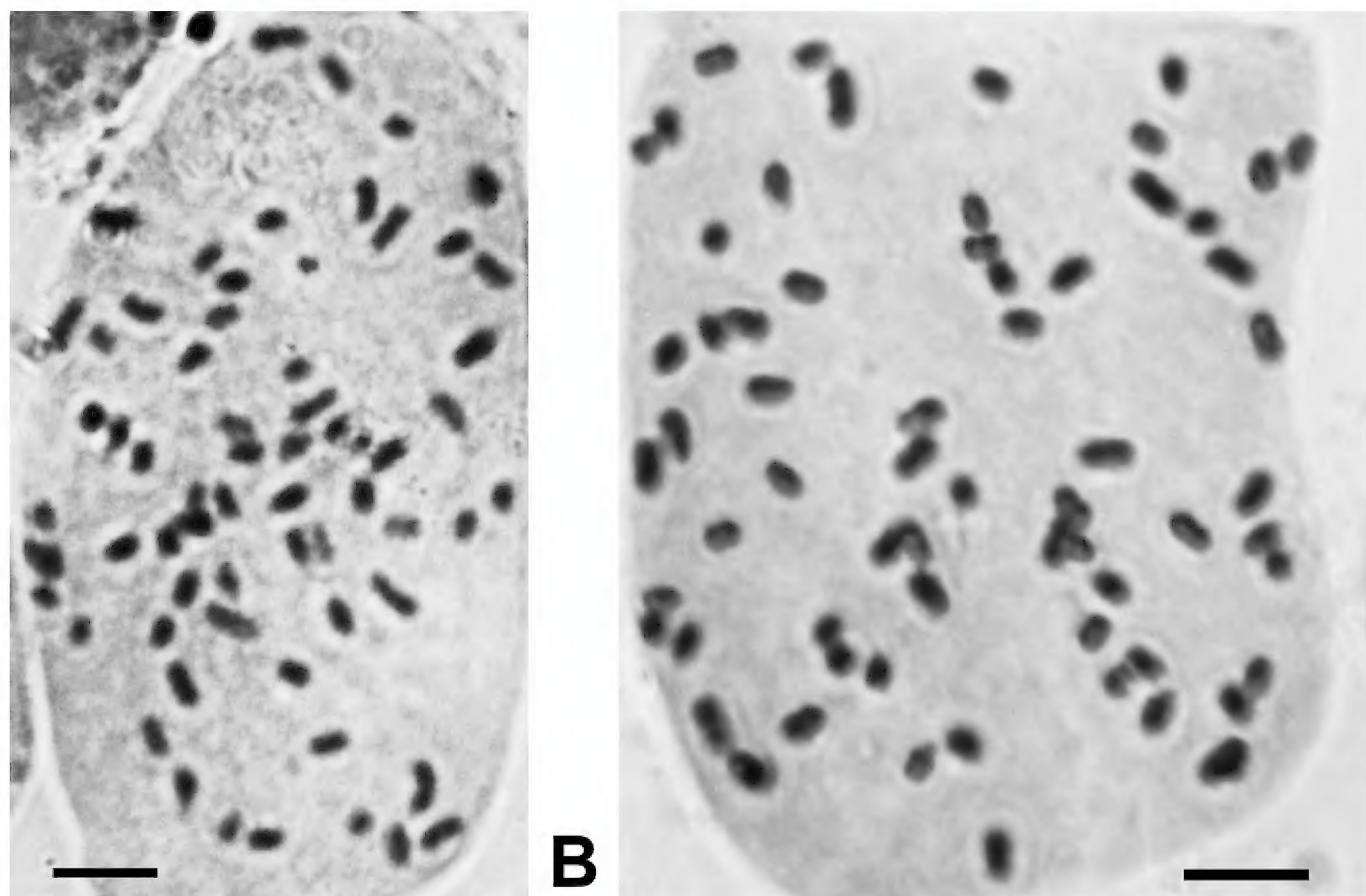


Figure 6. Chromosome number of the two species of *Cirsium* subsect. *Nipponocirsium* Kitam. in Taiwan. **A** $2n = 64$, *C. tatakaense* Y.H.Tseng & C.Y.Chang **B** $2n = 64$, *C. kawakamii* Hayata. Scale bar: 5 μm .

Chromosome number. $2n = 64$ (Fig. 6A)

Palynology. Pollen grains are tricolporate, spheroidal, microreticulate and $34.2\text{--}42.6 \times 35.2\text{--}44.7 \mu\text{m}$ (P/E ratio: 0.9–1.0). The surface of the pollen is densely covered with spines that are $3.2\text{--}5.1 \mu\text{m}$ long and $4.2\text{--}5.6 \mu\text{m}$ wide at the base. The distance between spines is $7.5\text{--}10.6 \mu\text{m}$ (Fig. 7A).

Conservation status. *Cirsium tatakaense* is distributed in central-southern Taiwan, with a population of more than 1000 mature individuals. Its habitats are mainly located in high and sunny mountain areas and many of them are difficult to locate. Therefore, following the International Union for Conservation of Nature (IUCN) Categories and Criteria (IUCN 2014), we regard this species as Least Concern. However, long-term monitoring of its population is still required.

Additional specimens examined (paratype). TAIWAN. Nantou County, Sinyi Township, Highway no. 18, Tataka to Shihshan, 2400 m alt., $23^{\circ}28.52'\text{N}$, $120^{\circ}52.10'\text{E}$, 3 Oct. 2016. C. Y. Chang 1442 (TCF); same loc., 3 Oct. 2016. C. Y. Chang 1443 (TCF); same loc., 12 Sept. 2012. C. T. Chao et al. 2534 (TNM!); Tunpu Hot Spring to Kuankao, 1300–2600 m alt., 3 July 1985. C. I Peng 8026 (HAST!). Chiayi County, Alishan Township, Alishan, 25 Dec. 1928. Y. Kudo & S. Suzuki 300 (TAI!); Tatachia saddle to Paiyunshanchuang, 2700–3000 m alt., 9 Nov. 1985. C. I Peng 8931 (HAST!); Tatachia saddle to Mt. Yushanchienfu, 2700–3100 m alt., 11 Nov. 1990. P. J. Wu et al. s. n. (TNM!). Kaohsiung City, Tauyuan District, Kuaiku to Yakou, 2600 m alt., $23^{\circ}16.03'\text{N}$, $120^{\circ}56.24'\text{E}$, 21 Oct. 2014. C. Y.

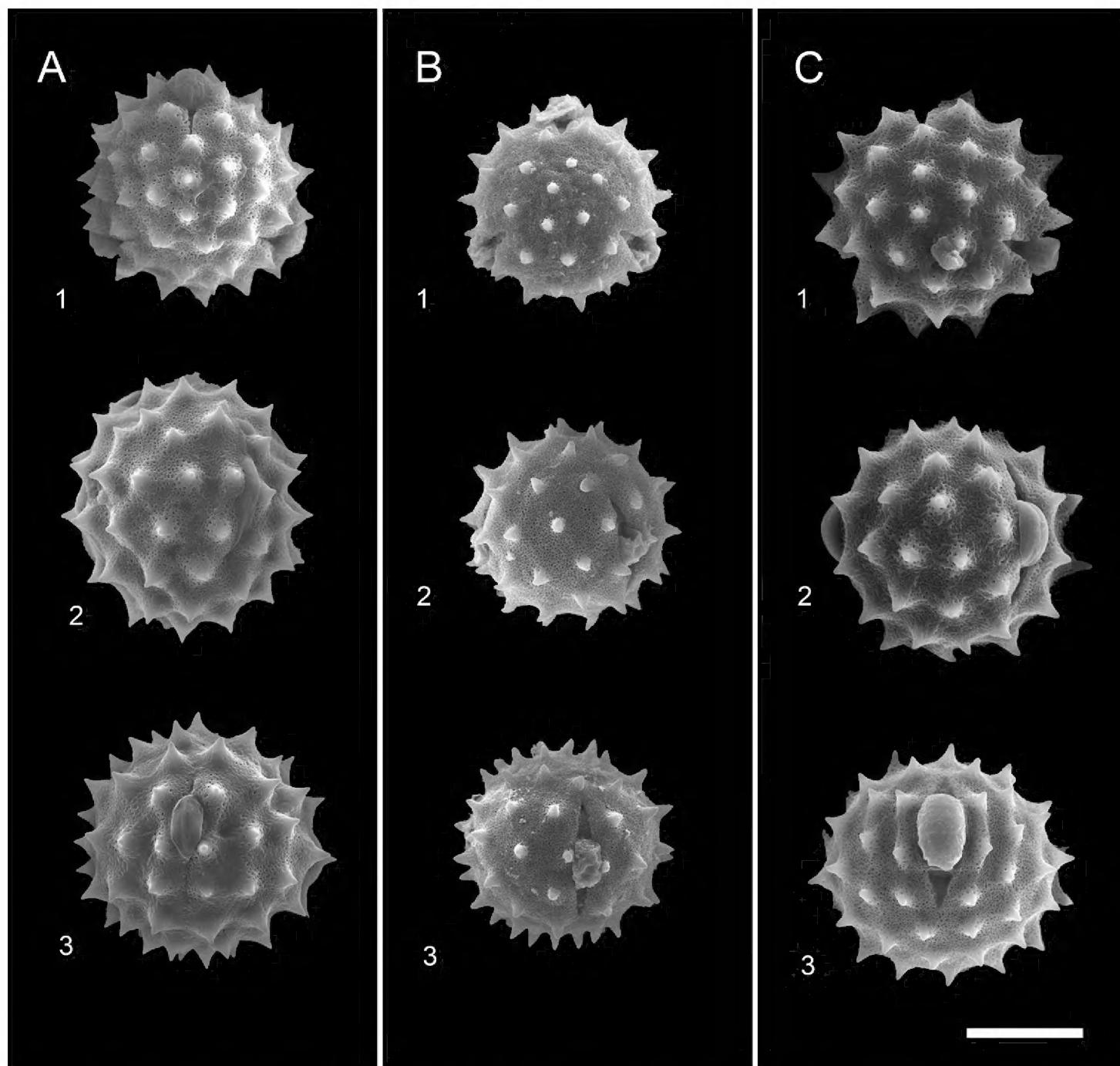


Figure 7. Comparison of the pollen morphology of the three species of *Cirsium* sect. *Onotrophe* in Taiwan. **A** *C. tatakaense* Y.H.Tseng & C.Y.Chang **B** *C. kawakamii* Hayata **C** *C. arisanense* Kitam.: **1** polar view **2** equatorial view **3** colporate view. Scale bar: 30 μ m.

Chang 160 (TNM); Gingzin bridge, 14 Sept. 1999. C. S. Kuoh 15146 (TAN!). Taitung County, Yanping Township, Yenping forest-road, 1500–1800 m alt., 2 July 2006. Y. J. Lin 169 (PPI!).

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References

Chen CM, Yeh MS (2010a) Mass propagation of medicinal plant, *Cirsium japonicum* DC *in vitro* and its chromosome number. *Seed & Nursery* 12(2): 33–47. [In Chinese]

Chen CM, Yeh MS (2010b) Micropropagation and chromosome number of *Cirsium brevicaule* A. Gray—A medicinal plant native in Taiwan. *Journal of Agriculture and Forestry* 59(4): 327–338. [In Chinese]

Erdtman G (1952) Pollen Morphology and Taxonomy. Stockholm Alomqvist and Wiksell, Sweden, 539 pp.

Funk VA, Susanna A, Stuessy TF, Bayen RJ (2009) Systematics, Evolution, and Biogeography of Compositae. International Association for Plant Taxonomy, Austria, 965 pp.

Hesse M, Halbritter H, Zetter R, Weber M, Buchner R, Frosch-Radivo A, Ulrich S (2009) Pollen Terminology an Illustrated Handbook. University of Vienna, 264 pp.

Hsu CC (1970) Preliminary chromosome studies on the vascular plants of Taiwan (III) The Aster Family, Compositae. *Taiwania* 15(1): 17–29.

IUCN (2014) The IUCN Red List of threatened species: Version 2013.2. IUCN Red List Unit, Cambridge. <http://www.iucnredlist.org> [Accessed: 15 January 2018]

Iwatsuki K, Yamazaki T, Boufford DE, Ohba H (1995) Flora of Japan Volume IIIb Angiospermae Dicotyledoneae Sympetalae (b). Kodansha (Tokyo): 119–151.

Kadota Y (2007) Species diversification of genus *Cirsium* (Asteraceae) in Japan. *Korean Journal of Plant Taxonomy* 37(4): 335–349. <https://doi.org/10.11110/kjpt.2007.37.4.335>

Kitamura S (1937) Compositae Japonicae XIII. *Memoirs of the College of Science, Kyoto Imperial University. Series B. Biology*, Kyoto, 421 pp.

Ozcan M, Sema HA, Huseyin I (2011) Chromosome reports in some *Cirsium* (Asteraceae, Cardueae) Taxa from North-East Anatolia. *Caryologia* 64(1): 55–66. <https://doi.org/10.1080/00087114.2011.10589764>

Peng CI (2003) *Cirsium*. In: Boufford DE, Hsieh CF, Kuo CS, Ohashi H, Su HJ (Eds) Flora of Taiwan, Vol. 4 (2nd edn). Editorial Committee of the flora of Taiwan, Taipei, 903–913.

Peng CI, Hsu CC (1978) Chromosome numbers in Taiwan Compositae. *Academia Sinica* 19: 53–66.

Shih Z (1984) Notulae de plant tribus Cynarearum family Pompositarum Sinicae (II). *Zhiwu Fenlei Xuebao* 22(5): 386–396.

Shih Z, Greuter W (2011) *Cirsium*. In: Chen DZ, Shimizu T (Eds) Flora of China, Vol. 20. Flora of China Editorial, Beijing, 160–175.

Su HJ (1984) Studies on the climatic and vegetation types of the natural forests in Taiwan (II) altitudinal vegetation zones in relation to temperature gradient. *Quarterly Journal of Chinese Forestry* 17(4): 57–73.

Su HJ (1985) Studies on the climate and vegetation types of the natural forests in Taiwan (3) – A scheme of geographical climatic regions. *Quarterly Journal of Chinese Forestry* 18(3): 33–44.

Yüksel E, Kiran Y, Şahin A, Yıldız B, Arabaci T (2013) Karyological studies of 10 *Cirsium* sect. *Epitrachys* (Asteraceae) species from Turkey. *Turkish Journal of Botany* 37: 1085–1092. <https://doi.org/10.3906/bot-1302-1>